#25/Appeal Brief 3/5/02

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Appln. Of: Hiroaki YOKOYAMA

Serial No.: 08/992,767

Filed: December 17, 1997

For: CONTACT STRUCTURE IN SEMICONDUCTOR INTEGRATED . . .

Group: 2814

Examiner: D. Wille DOCKET: NEC 19654

The Assistant Commissioner of Patents & Trademarks
Washington, D.C. 20231

APPELLANT'S BRIEF ON APPEAL

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Dear Sir:

APPELLANT'S BRIEF ON APPEAL

This Brief is being filed in support of Appellant's Appeal from the Final Rejection by the Examiner, the Notice of which was timely filed on October 1, 2001.

Real Party in Interest

The Real Party in Interest in this application is NEC Corporation. which has a place of business at 7-1. Shiba 5-chome, Minato-ku, Tokyo 108-01. JAPAN. NEC Corporation received an assignment of all right, title and interest in the application through an assignment executed by the inventor, Hiroaki Yokayama, on December 17, 1997 and by virtue of his employment by NEC Corporation. The assignment is recorded in the U.S. Patent and Trademark Office at Reel 8930, Frame 0303.

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Related Appeals and Interferences

There are no appeals or interferences that would directly affect. or be directly affected by, or have a bearing on the Board's decision in the present appeal.

Status of the Claims

Claims 11-28 stand rejected under 35 USC § 103(a) as being unpatentable over Tsoi et al. (U.S. Patent No. 5,631,484) in view of Roberts et al. (US Patent No. 5,730,835), McDavid (U.S. Patent No. 4,507,853), Miller et al. (US Patent No. 5,714,804), and Kim et al. (U.S. Patent No. 5,591,675).

Status of the Amendments

No claim changes were made after issuance of the Final Action. Thus. Amendment E. after Final, which merely contained arguments was entered by the Examiner.

Summary of the Invention

In the manufacture of semiconductor integrated circuits, contact electrodes are formed in the circuit to provide electrical connection to both internal and external components. In the prior art, as shown for example in Figures 1A and 1B. a contact hole 9 is formed in a silicon oxide insulator film 2 to expose a semiconductor substrate 1 in the area of a desired contact point. Page 1, lines 19-22[1]. Thereafter a wire conducting layer 8 is formed over the entire surface of the substrate and film 2. Page 1. line 23 to Page 2. line 1. Alternatively, as shown in Figures 2A through 2C. a layer of refractory material is deposited on the silicon oxide film 2 and then etched

1 References herein refer to drawing figures or page and line numbers of the specification in the present application.

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to leave only refractory sidewall 6 in the contact hole 9. Page 2, line 26 to Page 3, line 2. The wire conducting layer 8 is then deposited over the structure to extend down into the contact hole and in contact with the semiconductor substrate 1. Page 3, lines 16-19.

As the density of semiconductor integrated circuits has increased, it has become difficult to form contacts with sufficient contact resistance in relatively small contact holes. Page 2, lines 3-8 and Page 4, lines 14-19. In addition, in semiconductor integrated circuits having both relatively large-diameter contact holes and also relatively small-diameter contact holes, the prior art has failed to provide a method which allows for stable contact resistance in both the large-diameter and small-diameter holes. Page 4, lines 20-24. As discussed at page 4, line 25 to page 5, line 6, of the specification:

> "For example, when the sidewall of the refractory metal is formed to fit with small-diameter contact holes, it is necessary to form the refractory metal layer having a thin film thickness to ensure that the small-diameter holes are never completely filled by the refractory metal. However, if the refractory metal layer having the thin film thickness is formed, the film thickness of the sidewall of the refractory metal in the large-diameter contact holes becomes too thin, so that the aluminum wiring conductor layer will disconnect at the bottom of the contact hole, with the result that the contact resistance becomes high."

To overcome the deficiencies of the prior art, Appellant provides a semiconductor device that includes both large-diameter contact holes 3 and small-diameter contact holes 4 formed to penetrate an insulator film 2 to reach to a semiconductor substrate 1. Each of the large-diameter contact holes 3 and the small-diameter contact holes 4 have a funnel-shaped portion 3A or 4A formed on an upper portion thereof to open or spread upward, as shown, for example, in FIG. 6A. Page 13, lines 12-14. Then, "Excluding the funnel-shaped portion 3A, the small-diameter contact hole 4 is completely filled with a plug 7 of refractory conductive material." Page 13, lines 15-16. The large-diameter contact hole 3 is filled with a sidewall 6 formed of the refractory material covering in part a side surface of the hole 3 to "lower by a predetermined distance.

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Then a boundary 3D between a vertical side surface of the large-diameter contact hole 3 and the funnel-shaped portion 4A." Page 13, lines 19-22. A wiring conductor layer 8 is deposited to cover the upper surface of the device, as shown for example in FIG. 5. Advantages of this construction are discussed in the specification at page 15, line 21 to page 16, line 3:

> "... since the funnel-shaped portion 3A is formed to extend from the upper end of the large-diameter contact hole 3B and since the sidewall 6 of the refractory conductive material is formed to cover the side surface of the large-diameter contact hole 3B lower than the upper end 3D of the large-diameter contact hole 3B by the predetermined distance, the hole defined by the funnel-shaped portion 3A, the large-diameter contact hole 3B and the sidewall 6 has an upper end diameter larger than a bottom diameter, in other words, has a general shape which may be called a reverse-truncated cone."

As further noted in the specification, the invention provides significant advantages over prior art structures:

> "With this feature, even if the interlayer insulator film becomes thick or even if the contact hole becomes fine because of the advanced high integrated density and highly fine patterning of the semiconductor integrated circuit, the wiring conductor layer never disconnect at the bottom of the contact hole, with the result that the contact resistance is stable and low. Therefore, a small and stable contact resistance can be realized both in the large-diameter contact hole and in the small-diameter contact hole which are mixedly included in a semiconductor integrated circuit." (Page 16, lines 19-27).

Summary of Claims on Appeal

A limitation of all the claims of Appellant's application is a semiconductor device including both large-diameter contact holes and small-diameter contact holes formed to penetrate through an insulator film formed on a conductive portion to each of the conductive portions. Each of the large-diameter contact holes and the small-diameter contact holes have funnel-shaped portions formed on an upper portion thereof. The small-diameter contact holes are completely filled with a plug of refractory conductive material, while the large-diameter contact

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holes are partly filled with refractory conductive material covering a sidewall surface of the large-diameter contact hole excluding the funnel-shaped portions, to a location lower than the lower end of the funnel-shaped portions. A wiring conductive layer is deposited to cover a top surface of the plug refractory conductive material and fill at least in part the space remaining in the large-diameter contact hole, to cover a bottom of the large-diameter contact hole and a surface of the sidewall of the refractory conductive material within the large-diameter contact hole. Independent claim 11 further requires that each of the large-diameter contact holes and small-diameter contact holes have a constant-diameter portion formed on a lower portion thereof, while independent claim 20 requires that the refractory conductive material covering the sidewall surface of the large-diameter contact hole have a thickness on a lower portion of the hole equal to about half the diameter of the small-diameter contact hole.

Issues Presented on Appeal

1. Whether claims 11-28 are unpatentable under 35 USC § 103(a) as being obvious from Tsoi et al. in view of Roberts et al., McDavid, Miller et al. and Kim et al.

Grouping of Claims

There are two groups of claims on appeal: Group I comprising independent claim 11 and the several claims 12-19 which depend directly or indirectly thereon; and Group II comprising independent claim 20 and the several claims 21-28 which depend directly or indirectly thereon. The claims do not stand or fall together. as will be shown herein.

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Arguments

I. The rejection of claims 11-19 under 35 U.S.C. §103(a) as being unpatentable over Tsoi et al in view of Roberts et al., McDavid, Miller et al. and Kim et al.is in error.

The primary reference Tsoi et al. has been cited simply to show semiconductor devices having different sized vias for contacts. As such, Tsoi et al. is no different from the acknowledged prior art discussed in Appellant's specification, except that Tsoi et al. fails to even mention coverage problems when different sized vias are present. Indeed, the Examiner acknowledges Tsoi et al. fails to discuss coverage problems (Final Action paragraph 3, lines 2-3). Significantly, Tsoi et al. not only fails to teach or suggest that potential coverage problems exist with semiconductor devices having both large-diameter and small-diameter contact holes, i.e. contact holes having different aspect ratios, Tsoi et al. simply suggests that by making the contact holes wide enough, there are no contact problems. See, for example, column 5, lines 12-16, in which Tsoi et al. report:

> "Also, according to the present invention, opening 62 preferably has a width such that a portion 129 of major surface 29 remains between spacers 58 and opening 62. This provides for improved contact to substrate 26 after subsequent processing described below."

Additionally, the primary reference Tsoi et al. fails to teach or suggest a funnel-shaped portion formed on an upper portion of any of the vias as required by independent claim 11.

It is not seen that the secondary references supply the missing teachings to Tsoi et al. to achieve or render obvious claim 11, or any of the claims dependent thereon.

Roberts et al. teaches a method for providing improved step coverage of contacts with conductive materials. As shown in FIGS. 2-4 of Roberts et al., a first conductive layer 14 is

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deposited over an insulating layer 12. Col. 5, lines 19-20. A contact opening or contact 20 may be formed, either before or after depositing of the layer 14, through the insulating layer 12 to the circuit element 10. Col 5, lines 20-24. A facet etch is performed to slope the conductive layer overlying the contact opening lip 27. Col. 6, lines 6-8. The etched material is deposited into the lower corner of the contact. Col. 6, lines 35-40. A second conductive layer 40 may then be deposited into the contact to supplement coverage provided by the first conductive layer and the facet etch. Col. 6, lines 63-64.

Roberts et al. also is completely devoid of any teaching or suggestion of "A semiconductor device including both a large-diameter contact hole and a small-diameter contact hole" wherein the small-diameter hole is "completely filled" with a refractory conductive material while the large-diameter hole is partly filled with the refractory conductive material which "covers a sidewall surface of said large-diameter hole excluding said funnel-shaped portion, to a position which is lower than a lower end of said funnel-shaped portion by a predetermined distance" as required by independent claim 11

On the contrary, Roberts et al. teaches only partly filling a hole with a conductive material which is sputtered into the corners of the hole during the process of creating a facet etch. See, for example, column 6, lines 35-52, wherein it is stated:

> "As illustrated in FIG. 3, the material removed from the upper corner 26 (FIG. 2) of the first conductive layer 14 also acts as a sputter deposition target, so that at least some of the conductive material of the upper corner 26 (FIG. 2) is deposited into a lower corner 30 of the contact 20 to form a conductive corner fill 32 (FIG. 3). FIGS. 2 and 3 show a cross-sectional view of the contact 20, wherein the backwall is omitted from the views for simplicity. Material sputtered from the upper corner 26 on a right side 36 of the contact 20 is deposited in the lower corner 30 on a left side 37. Conversely, material sputtered from the upper corner 26 on the left side 37 is deposited in the lower corner on the right side 36.

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> Similarly, material from every point of the upper corner 26 all around the mouth of the contact 20 are sputtered to a point diagonally opposite in the lower corner 30, forming an annulus (doughnut shape) of conductive material which has been referred to as the corner fill 32 of the present invention." (emphasis added).

There is simply nothing in Roberts et al. which teaches a device having both large and small-diameter holes, as required by claim 11. Moreover, there is nothing in Roberts et al. which even remotely suggests partial filling of a large-diameter contact hole and complete filling of a small-diameter contact hole as required by claim 11. In fact, Roberts et al. teaches away from the claimed invention by teaching localized partial filling of a contact hole by sputtering material from a facet etch. Even if small-diameter holes were disclosed in Roberts et al., the sputtering of material into the large-diameter contact hole of Roberts et al. belies the notion that there could be complete filling of small-diameter holes.

McDavid is equally remote. McDavid, like Roberts et al., also fails to teach or suggest semiconductor devices including both large-diameter contact holes and small-diameter contact holes as required by Appellant's claim 11. Thus, McDavid, like Roberts et al., also fails to encounter or address the technical problems to which the subject application is directed, namely, assuring stable contact resistance in both large-diameter contact holes and small-diameter contact holes in an integrated circuit. McDavid has been cited as teaching "a technique of forming a metalization in a via ... where the corner filling 13 is formed by anisotropically etching a preliminary metal layer." However, Appellant has not claimed to have invented, per se, isotropic etching of a preliminary metal layer. McDavid's contribution to the art is a two-step metal deposition sequence to enhance step coverage in which a first layer of metal is deposited in a hole, an anistropic etch is employed to remove vertical portions of the deposited metal, and a second layer of metal is then deposited. McDavid, like Tsoi et al. and Roberts et al., fails to

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teach or suggest a device having both large- and small-diameter contact holes as required by claim 11. Nor does McDavid discuss there could be different problems in filling large-diameter contact holes and small-diameter contact holes. Indeed, McDavid treats all of his contact holes the same, filling the contact holes with the same material, thus suggesting that there is no problem where both large- and small-diameter holes are present. Appellant's claim 11, on the other hand, requires that the small-diameter contact holes be completely filled with a refractory conductive material, while the large-diameter contact holes are partly filled with the refractory conductive material, and party filled with the wiring conductive material.

Miller et al. similarly is inapposite. Miller et al. has been cited to "show the formation of a metalized via … for high aspect ratio holes." (Final Rejection, page 3, lines 5-6).

Miller et al. teaches a structure, as shown in FIGS. 4-6 thereof, for protecting a barrier metal layer 2 within a contact opening 30 during formation of an aluminum interconnection layer 6 overlying a tungsten plugged connection structure. Col. 5, lines 23-24. The deposited tungsten plug 20 overlying the barrier metal layer 2 is etched back sufficiently to create a slight recess 31 at the opening. Col. 5, lines 57-59. A thin layer of tungsten 22 is then selectively deposited for filling the recess 31. Col. 6, lines 17-20. The layer of tungsten 22 acts as an etch stop during interconnection layer formation and protects the underlying barrier metal layer. Col. 6. lines 20-24.

The Examiner cites Miller et al. as teaching:

> "It would have been obvious to use to use (sic) the method shown above for the low aspect ratio holes and to use the Miller et al. technique for the high aspect ratio holes …" (Final Action, page 3, lines 6-8).

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This demonstrates the extent to which the Examiner has cherry-picked teachings of the several prior art references, taking them out of context, and, employing the Application on Appeal as a roadmap, combine the references to make out a case for obviousness. Independent claim 11, requires that the small-diameter contact hole "penetrate through an insulator film formed on a conductive portion to reach said conductive portion", and that the small-diameter hole be "completely filled" with refractory material simultaneously while the large-diameter contact hole is partly filled. It is abundantly clear that hole 30 in Miller et al. is not "completely filled" by refractory material, as required by independent claim 11. Instead, as shown, for example, in the cover figure, a barrier metal layer 2 is formed in the contact hole to cover the sidewalls thereof and the exposed portion of the substrate 10. The plug 20 is then deposited over the barrier metal layer 2.

Moreover there is nothing in Miller et al. which teaches or suggests a device having both small and large-diameter contact holes. There cannot, therefore, be said to be any teaching or suggestion of a device wherein a <u>large-diameter contact hole</u> is partially filled and a <u>small-diameter contact</u> hole is completely filled by a refractory material, as required by claim 11. Again, Miller et al. does not even teach complete filling of a small-diameter hole by a refractory plug. Miller et al. is also completely devoid of any teaching or suggestion of a device wherein each large-diameter contact hole and each small-diameter contact hole has a "funnel-shaped portion" on an "upper portion thereof", as required by independent claim 11, and the several claims which depend therefrom.

Further, with regard to the foregoing, and with specific reference to the claim limitation that the upper areas of the holes have a "funnel-shaped portion", here the Examiner refers to yet a fifth reference, Kim et al. Kim et al. has been cited as teaching "a method of forming

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metalization in a via ... where the upper surface of the via is wider, which effectively reduces the aspect ratio." (See the sentence bridging pages 2-3 of the Final Action). However, Kim et al., like Roberts et al. and Miller et al. discussed at length above, also fails to teach a device having both large and small-diameter holes. Kim et al.'s contribution to the art is to create tapered wall holes specifically to avoid problems in the prior art of constant diameter holes. See Kim et al. Prior Art Figs. 1A-1E and columns 1-2. Appellant's claim 11 requires that both the large-diameter contact hole and the small-diameter contact hole have constant diameter portions on a lower portion thereof. Thus, and since Kim et al. teaches against constant diameter contact holes, it would not be obvious to one skilled in the art to combine the teachings of Kim et al. with the several other references above discussed to make out a case for obviousness, since Kim et al. specifically teaches against constant diameter contact holes.

Appellant's claimed semiconductor device essentially comprises four elements: (1) a substrate; (2) an insulator film having large-diameter contact holes and small-diameter contact holes; (3) refractory conductive material; and, (4) a wiring conductive material. Notwithstanding, the Examiner has found it necessary to combine five different references in an attempt to make out a case for obviousness. The fact that the Examiner has found it necessary to cite five references to make a claim essentially involving only four elements clearly bespeaks to the non-obviousness of the subject claimed invention.

In addition to failing to cite references which teach or suggest all of the claimed limitations, either alone or in combination, the Examiner has failed to meet the requirement of clearly and particularly identifying actual evidence of a suggestion, teaching, or motivation to combine references. Instead, the Examiner has merely provided "broad conclusory" statements, in a manner which has explicitly been rejected by the Court of Appeal for the Federal Circuit.

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See, <u>In re Dembiczak</u>, 50 USPQ2d, 1614 (Fed.Cir. 1999). For example, the Examiner has argued that:

> "It would have been obvious to modify the Roberts et al. technique to form the corner filling using the McDavid method so that it is not necessary to maintain an upper metal layer and to apply this technique to Tsoi et al. to improve step coverage. Kim et al. show a method of forming metallization in a via … where the upper surface of the via is wider, which effectively reduces the aspect ratio … Roberts et al. also show the fluted upper area of the via. It would have been obvious to specifically include this feature to reduce the aspect ratio and thus improve coverage. While Tsoi et al. do not specify the aspect ratio of the vias it would be expected that, in practice, it would be desirable to form vias without concern for the aspect ratio. Miller et al. show the formation of a metallized via … for high aspect ratio holes. It would have been obvious to use the use the (sic) method shown above for the low aspect ratio holes and to use the Miller et al. technique for the high aspect ratio holes and to use the fluted upper area of the hole as shown by Kim et al. for all the holes." (Final Action, pages 2-3).

These statements simply do not provide a clear and particular showing of a suggestion or motivation to combine the references in the manner suggested by the Examiner, particularly when considered in light of specific contraindications in the prior art to elements of the claimed invention, as discussed above. The Examiner has, therefore, failed to establish a *prima facia* case of obviousness.

Thus, none of the art, alone or in combination, teaches or suggests a "A semiconductor device including both a <u>large-diameter contact</u> hole and a <u>small-diameter contact hole</u>" wherein each hole has a "constant-diameter portion formed on a lower portion thereof, and a funnel-shaped portion formed on an upper portion thereof," the small-diameter hole is "<u>completely filled</u>" with a refractory conductive material and the large-diameter hole is partly filled with refractory material "covering a sidewall surface of said funnel-shaped portion of said large-

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diameter contact hole, to a position lower than the lower end of the funnel-shaped portion by a predetermined distance", as required by independent claim 11.

Accordingly, the rejection of claim 11 as obvious from the art is in error.

Claims 12-19 depend directly or indirectly from claim 11, and are allowable for the same reasons adduced relative to claim 11, as well as for their own additional limitations. (35 USC § 112). Thus, the rejection of claims 11-19 also is in error.

II. The rejection of claims 20-28 under 35 U.S.C. §103(a) as being unpatentable over Tsoi et al. in view of Roberts et al., McDavid, Miller et al. and Kim et al. is in error.

Independent claim 20 is similar to independent claim 11 discussed above in requiring a semiconductor device including both a large-diameter contact hole and a small-diameter contact hole formed to penetrate through an insulator film. Independent claim 20 similarly requires that the large-diameter contact hole and the small-diameter contact hole have funnel-shaped portions formed on an upper surface thereof. Independent claim 20 also requires that the small-diameter contact hole be completely filled with a plug of refractory conductive material, while the large-diameter contact hole is partly filled by the refractory conductive material to a position lower than the lower end of the funnel-shaped portion. Independent claim 20 similarly requires a wiring conductive layer deposited on the insulator film to cover a top surface of the plug and the refractory conductive material and fill at least in part space remaining in the large-diameter contact hole to cover a bottom of the large-diameter contact hole and a surface of the sidewall of the refractory conductive material within the large-diameter contact hole, and to cover a surface of the funnel-shaped portion of the large-diameter contact hole. However, unlike claim 11, claim 20 further specifies that the refractory conductive material covering the sidewall surface of the

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large-diameter contact hole have a thickness on a lower portion of the hole, equal to about half the diameter of the small-diameter contact hole. This latter feature is not taught by any of the art of record.

As noted supra as regards the rejection of claims 11-19, the primary reference Tsoi et al. has been cited simply to show semiconductor devices having different sized vias for contacts. As such, Tsoi et al. is no different from the acknowledged prior art discussed in Appellant's specification, except that Tsoi et al. fails to even mention coverage problems when different sized vias are present. Indeed, the Examiner acknowledges Tsoi et al. fails to discuss coverage problems (Final Action paragraph 3, lines 2-3). Significantly, Tsoi et al. not only fails to teach or suggest that potential coverage problems exist with semiconductor devices having both large-diameter and small-diameter contact holes, i.e. contact holes having different aspect ratios, Tsoi et al. simply suggests that by making the contact holes wide enough, there are no contact problems. See, for example, column 5, lines 12-16, in which Tsoi et al. report:

> "Also, according to the present invention, opening 62 preferably has a width such that a portion 129 of major surface 29 remains between spacers 58 and opening 62. This provides for improved contact to substrate 26 after subsequent processing described below."

Additionally, the primary reference Tsoi et al. fails to teach or suggest a funnel-shaped portion formed on an upper portion of any of the vias, or a refractory conductive metal covering the sidewall surface of the large-diameter contact holes having a thickness on a lower portion of the hole, equal to about half the diameter of the small-diameter contact hole as required by claim 20. How could he? Tsoi et al. doesn't have both large- and small-diameter holes!.

It is not seen that the secondary references supply the missing teachings to Tsoi et al. to achieve or render obvious claim 20, or any of the claims dependent thereon.

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As noted supra as regards to the rejection of claims 11-19, Roberts et al. teaches a method for providing improved step coverage of contacts with conductive materials. As shown in FIGS. 2-4 of Roberts et al., a first conductive layer 14 is deposited over an insulating layer 12. Col. 5, lines 19-20. A contact opening or contact 20 may be formed, either before or after depositing of the layer 14, through the insulating layer 12 to the circuit element 10. Col 5, lines 20-24. A facet etch is performed to slope the conductive layer overlying the contact opening lip 27. Col. 6, lines 6-8. The etched material is deposited into the lower corner of the contact. Col. 6, lines 35-40. A second conductive layer 40 may then be deposited into the contact to supplement coverage provided by the first conductive layer and the facet etch. Col. 6, lines 63-64.

Roberts et al. also is completely devoid of any teaching or suggestion of "A semiconductor device including both a large-diameter contact hole and a small-diameter contact hole" wherein the small-diameter hole is "completely filled" with a refractory conductive material while the large-diameter hole is partly filled with the refractory conductive material which "covers a sidewall surface of said large-diameter hole excluding said funnel-shaped portion, to a position which is lower than a lower end of said funnel-shaped portion by a predetermined distance" as required by independent claim 20

On the contrary, Roberts et al. teaches only partly filling a hole with a conductive material which is sputtered into the corners of the hole during the process of creating a facet etch. See, for example, column 6, lines 35-52, wherein it is stated:

> "As illustrated in FIG. 3, the material removed from the upper corner 26 (FIG. 2) of the first conductive layer 14 also acts as a sputter deposition target, so that at least some of the conductive material of the upper corner 26 (FIG. 2) is deposited into a lower corner 30 of the contact 20 to form a conductive corner fill 32 (FIG. 3). FIGS. 2 and 3 show a cross-sectional view of the contact 20, wherein the backwall is omitted from the views for simplicity.

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> Material sputtered from the upper corner 26 on a right side 36 of the contact 20 is deposited in the lower corner 30 on a left side 37. Conversely, material sputtered from the upper corner 26 on the left side 37 is deposited in the lower corner on the right side 36. Similarly, material from every point of the upper corner 26 all around the mouth of the contact 20 are sputtered to a point diagonally opposite in the lower corner 30, forming an annulus (doughnut shape) of conductive material which has been referred to as the corner fill 32 of the present invention." (emphasis added).

There is simply nothing in Roberts et al. which teaches a device having both large and small-diameter holes, as required by claim 11. Moreover, there is nothing in Roberts et al. which even remotely suggests partial filling of a large-diameter contact hole and complete filling of a small-diameter contact hole as required by claim 20. In fact, Roberts et al. teaches away from the claimed invention by teaching localized partial filling of a contact hole by sputtering material from a facet etch. Even if small-diameter holes were disclosed in Roberts et al., the sputtering of material into the large-diameter contact hole of Roberts et al. belies the notion that there could be complete filling of small-diameter holes.

McDavid is equally remote. As noted supra as regards the rejection of claims 11-19, McDavid, like Roberts et al., also fails to teach or suggest semiconductor devices including both large-diameter contact holes and small-diameter contact holes as required by Appellant's claim 20. Thus, McDavid, like Roberts et al., also fails to encounter or address the technical problems to which the subject application is directed, namely, assuring stable contact resistance in both large-diameter contact holes and small-diameter contact holes in an integrated circuit. McDavid has been cited as teaching "a technique of forming a metalization in a via … where the corner filling 13 is formed by anisotropically etching a preliminary metal layer." However, Appellant has not claimed to have invented, per se, isotropic etching of a preliminary metal layer. McDavid's contribution to the art is a two-step metal deposition sequence to enhance step

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coverage in which a first layer of metal is deposited in a hole, an anistropic etch is employed to remove vertical portions of the deposited metal, and a second layer of metal is then deposited. McDavid, like Tsoi et al. and Roberts et al., fails to teach or suggest a device having both large- and small-diameter contact holes as required by claim 20. Nor does McDavid discuss there could be different problems in filling large-diameter contact holes and small-diameter contact holes. Indeed, McDavid treats all of his contact holes the same, filling the contact holes with the same material, thus suggesting that there is no problem where both large- and small-diameter holes are present. Appellant's claim 20, on the other hand, requires that the small-diameter contact holes be completely filled with a refractory conductive material, while the large-diameter contact holes are partly filled with the refractory conductive material, and party filled with the wiring conductive material.

Miller et al. similarly is inapposite. Miller et al. has been cited to "show the formation of a metalized via … for high aspect ratio holes." (Final Rejection, page 3, lines 5-6).

Miller et al. teaches a structure, as shown in FIGS. 4-6 thereof, for protecting a barrier metal layer 2 within a contact opening 30 during formation of an aluminum interconnection layer 6 overlying a tungsten plugged connection structure. Col. 5, lines 23-24. The deposited tungsten plug 20 overlying the barrier metal layer 2 is etched back sufficiently to create a slight recess 31 at the opening. Col. 5, lines 57-59. A thin layer of tungsten 22 is then selectively deposited for filling the recess 31. Col. 6, lines 17-20. The layer of tungsten 22 acts as an etch stop during interconnection layer formation and protects the underlying barrier metal layer. Col. 6, lines 20-24.

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The Examiner cites Miller et al. as teaching:

> "It would have been obvious to use to use (sic) the method shown above for the low aspect ratio holes and to use the Miller et al. technique for the high aspect ratio holes ..." (Final Action, page 3, lines 6-8).

This demonstrates the extent to which the Examiner has cherry-picked teachings of the several prior art references, taking them out of context, and, employing the Application on Appeal as a roadmap, combined the references to make out a case for obviousness. Independent claim 20, requires that the small-diameter contact hole "penetrate through an insulator film formed on a conductive portion to reach said conductive portion", and that the small-diameter hole be "completely filled" with refractory material simultaneously while the large-diameter contact hole is partly filled. It is abundantly clear that hole 30 in Miller et al. is not "completely filled" by refractory material, as required by independent claim 20. Instead, as shown, for example, in the cover figure, a barrier metal layer 2 is formed in the contact hole to cover the sidewalls thereof and the exposed portion of the substrate 10. The plug 20 is then deposited over the barrier metal layer 2.

Moreover there is nothing in Miller et al. which teaches or suggests a device having both small and large-diameter contact holes. There cannot, therefore, be said to be any teaching or suggestion of a device wherein a <u>large-diameter contact hole</u> is partially filled and a <u>small-diameter contact</u> hole is completely filled by a refractory material, or of a refractory metal covering the sidewall surface of the large-diameter contact holes having a thickness on a lower portion of the hole, equal to about half the diameter of the small-diameter contact hole as required by claim 20. Again, Miller et al. does not even teach complete filling of a small-diameter hole by a refractory plug. Miller et al. is also completely devoid of any teaching or

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suggestion of a device wherein each large-diameter contact hole and each small-diameter contact hole has a "funnel-shaped portion" on an "upper portion thereof", as required by independent claim 20, and the several claims which depend therefrom.

Further, with regard to the foregoing, and with specific reference to the claim limitation that the upper areas of the holes have a "funnel-shaped portion", here the Examiner refers to yet a fifth reference, Kim et al. Kim et al. has been cited as teaching "a method of forming metalization in a via … where the upper surface of the via is wider, which effectively reduces the aspect ratio." (See the sentence bridging pages 2-3 of the Final Action). However, Kim et al., like Roberts et al. and Miller et al. discussed at length above, also fails to teach a device having both large and small-diameter holes.

None of the art, alone or in combination, teaches or suggests a "A semiconductor device including both a large-diameter contact hole and a small-diameter contact hole" wherein each having a "constant-diameter portion formed on a lower portion thereof, and a funnel-shaped portion formed on an upper portion thereof," the small-diameter hole is "completely filled" with a refractory conductive material and the large-diameter hole is partly filled with refractory material "covering a sidewall surface of said funnel-shaped portion of said large-diameter contact hole, to a position lower than the lower end of the funnel-shaped portion by a predetermined distance", as required by independent claim 20. Nor is there any teaching or suggestion in any of the references cited by the Examiner, of a semiconductor device as above described and claimed, in which the refractory conductive material covering the sidewall surface of the large-diameter contact hole has a thickness on a lower portion of the hole, equal to about half the diameter of the small-diameter contact hole, as required by claim 20.

Accordingly, the rejection of claim 11 as obvious from the art is in error.

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Claims 21-28 depend directly or indirectly from claim 20, and are allowable for the same reasons adduced relative to claim 20, as well as for their own additional limitations. (35 USC §112). Thus, the rejection of claims 21-28 also is in error.

SUMMARY

The combined teachings of the prior art neither teach nor suggest the claimed invention. Moreover, the art not only failed to recognize the problem addressed by the instant invention, the art actually suggested that the problem addressed did not exist. Therefore, the Examiner has failed to establish a prima facie case of obviousness.

Respectfully submitted,

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CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as First Class Mail in an envelope addressed to: Assistant Commissioner of Patents, Washington, D.C. 20231, Attention: Board of Patent Appeals and Interferences on November 29, 2001, at Tucson, Arizona.

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